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EVIDENCES OF QUALITY AND PALATABILITY IN BEEF

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Introduction

Beef has a very wide range of quality which is reflected in a correspondingly wide range in palatability, or in those properties that please the taste. Because of its variations in these respects, the amateur in selecting beef for the quality and palatability desired is often more disappointed than delighted with his choice.

Quality and palatability have been defined by meat research workers as follows: 1/

> Quality: Quality as applied to uncooked meat embraces all of those properties that point to the relative desirability or excellence of the cooked meat. In a technical sense, the evaluation of quality is dependent upon all of the properties of muscle, fat, and bone, including cartilage. The principal properties in the muscle are texture, grain, color, and firmness. The principal properties in the fat are texture, color, and firmness. The principal properties in the bone, including cartilage, are color and hardness.
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> Palatability: Palatability in any given meat is the degree in which it is acceptable, pleasing, agreeable, or satisfying to the palate, with special reference to flavor and tenderness or physical condition as experienced in the act of eating.

1/ Definitions approved by Committee of interbureau and State experiment station meat research workers, October 21, 1938.

Quality and palatability are invisible and intangible. There are, however, certain features or characteristics in meat that are visible and tangible and that indicate its degree of quality and palatability. Beef, for instance, has many such features or characteristics. Some of these will be analyzed in this discussion. Although the evidences of quality and palatability are present in the beef in varying degrees and most of them are recognized and used by those familiar with beef to judge the quality of the uncooked meat and to estimate its palatability when cooked, their exact significance and relationships to quality and palatability have not been reduced to precision. The problem, therefore, for one who is trying to select beef of the quality and palatability desired, or who is grading beef, is to recognize and carefully evaluate the known evidences of quality and palatability before forming final judgment.

The research studies relating to quality and palatability in meats conducted in recent years by Federal and State experiment stations have contributed materially to the fund of knowledge of meats in these respects. Much also has been learned of these evidences of quality in meats by Federal meat graders whose judgment is tested many times each working day. Data and information from these sources have been used freely in the analyses of the evidences of quality and palatability in beef in the following pages. In these analyses an effort has been made to select such features in beef as are most commonly used when estimating its quality and palatability, and to discuss their significance and practical application to this problem.

Grade and Quality

The grade of meat is determined by an evaluation of three natural or inherent factors which must be appraised singly and in combination. They are conformation, finish, and quality.

Conformation is the natural shape, form, or build of the carcass, or of the cut of meat and indicates especially the relative thickness of the meat or the proportion of edible meat to bone. Finish is primarily fat. It includes the quantity, character, and distribution of fat. Beef that is fully and desirably finished has attained sufficient but not the utmost degree of fatness. It has the degree of fatness that is characteristic of the most desirable beef, such as is found in the Prime and Choice grades. Quality in uncooked meat is the combination of all those inherent properties, including even factors of conformation and finish, which determine its relative degree of excellence and indicate its probable degree of palatability or desirability when the meat is cooked. See definition of quality on page 1.

Each of the three grade factors has many contributing elements which exist in varying degrees. The correct evaluation of these elements determines the relative value of their grade factor. The resulting values of each of the three factors thus determined are combined and given a final appraisal when the grade is determined.

Of the three factors, quality is by far the most important, especially from the standpoint of the consumer. It is, therefore, the most important factor to be considered by the grader and by the meat distributor. Conformation and finish are easily seen, they are tangible and their significance in relation to grade can be easily determined. Quality, on the other hand, is intangible and invisible, and can be estimated only by component and contributing elements, most of which can be seen, identified, and used as evidences of quality and of the degree to which it is present in the uncooked meat. The determination of quality requires an intimate knowledge of those elements and of their significance and relationship to the quality of the uncooked meat and to the palatability of the cooked meat.

Quality and Palatability

Quality and palatability as applied to meats are terms often used synonymously. For the purpose of this discussion, however, quality is arbitrarily limited to uncooked meat, while palatability is used to refer to the degree of satisfaction or enjoyment experienced when the cooked meat is eaten. The palatability of meat may be considered as proof of its quality. Quality, as one of the three grade factors, when applied to uncooked meat refers to those properties inherent in meat which determine its relative degree of excellence, and which, when the meat is cooked and eaten, determine its relative degree of palatability as registered by the senses of smell, taste, and touch (chewing). Quality in uncooked meat, therefore, appears to be the primary source of palatability in the cooked meat, and the degree to which it is present in the uncooked meat indicates the degree of palatability that may be expected when the meat is properly cooked. Quality and palatability, in this sense, imply the full range of excellence or desirability from the most desirable to the least desirable and, therefore, the many variations between these extremes.

Quality is not tangible and therefore not measurable but may be estimated with a reasonable degree of accuracy by one who is thoroughly familiar with meat and trained to detect and appraise the characteristics that are associated with or that are evidences of quality. Consequently, it is possible that the quality of uncooked meat and therefore the palatability of cooked meat may be estimated approximately by carefully appraising certain visible and tangible characteristic features in the uncooked meat that are known to be fairly reliable indications of its quality and that by experience are known to be indications of its palatability.

Quality and Palatability Related to Age and Finish

Many of the elements that indicate quality and palatability in beef are associated with tenderness, flavor, and juiciness and these in turn are believed to be related directly or indirectly to the general age of the animal and to its degree of finish or fatness when it was slaughtered. The approximate age of the animal is reflected in

the character of its meat. The most marked changes in the character of meat occur during the first 2 years of the animal's life. Although the changes are gradual there are four general stages according to age during the early life of the animal, namely, veal, calf, yearling beef, and mature beef. These stages are distinguishable by the obvious characteristics in the meat that are more or less peculiar to each general age group.

Along with the changes in the character of the meat due to age, there are changes in quality and palatability, especially in tenderness, flavor, and juiciness that are more or less peculiar to the age group in which they occur. For example, the tenderness, flavor, and juiciness of veal are not like those of the flesh of a 7-month-old calf, of a yearling, or of mature beef of the same grade. Neither are those of the beef of any age group exactly like those of any other age group. These changes continue after maturity but they are not so pronounced as during the first 20 or 24 months of the animal's life. The changes due to age are reflected in the color and consistency of the lean, fat, and bone, in the grain and texture of the lean, and in general conformation of the carcass.

The degree of finish or fatness apparently exerts a material influence on tenderness, juiciness, and flavor and, therefore, on quality and palatability of the flesh of an animal of any age. Many of the indications of quality and of palatability are associated with the color, amount, character or quality, and distribution of the fat. It is generally recognized, however, that beef in the higher grades is usually held to ripen for a longer period than lower grade beef. High-grade beef, therefore, usually has a greater opportunity for tenderization than low-grade beef. The aging or tenderization process not only affects its tenderness but also its flavor and probably its juiciness. (See pages 16-18.)

Exceptions to General Rules

All products of nature, including beef, have infinite variability and because of that variability there are few specific rules that are applicable in the determination of quality and palatability of beef, that do not have their possible exceptions. The problem for the one selecting or grading beef is to recognize the exceptions when they are apparent and, with the aid of the other indexes and a knowledge of their significance, to make adjustments in judgments accordingly. For instance, the general rules that apply to the quality and palatability of steer, heifer, and young cow beef are not always applicable, except in a broad way, to those of bull, stag, and old cow beef. There also are exceptions to the general rule that lean beef has the brightest shade in the highest grades, and that it has the darkest color in the lowest grades. As a rule, these and other exceptions present no serious problems to those familiar with beef and its characteristics. Decisions are reached after evaluating all known features that are indicative of quality and palatability, with due consideration for the possible exceptions.

The results of one series of palatability studies by several State experiment stations and the Department of Agriculture in which the ribs of over 700 cattle of various types, ages, and grades were used do not show a very close correlation between the palatability factors and the grades. The results of these studies therefore seem to be somewhat at variance with the popular concept of palatability in relation to grade. Consumers are willing to pay higher prices for the better grades of beef than for the lower grades, undoubtedly because the beef in the higher grades is more pleasing to the taste, i.e. more palatable than that in the lower grades.

Indications of Quality and Palatability

As previously indicated, the age of the animal and its degree of finish at time of slaughter have a material influence on its quality and on its palatability. The characteristics or elements, most of which are related directly or indirectly to age and finish and which are most generally observed when judging the quality of beef, are: the color and hardness of bone; color, consistency, and hardness of cartilage; the color, firmness, moisture, grain, and texture of lean; the color, character, quality, quantity, and distribution of fat, including marbling and the invisible fats or the intermingling of fats and oils within the lean; the apparent degree of tenderness of the lean; and the relative attractiveness or "eye appeal" of the meat.

Color and Hardness of Bone: The color and hardness of bone, also the color, consistency, and hardness of the cartilage, are indications of the age of the animal when slaughtered. Because of variations in the soil, vegetation, feeds, and water in various sections of the country, animals of the same age from different sections often apparently have varying degrees of color and hardness of bone. For instance, hardness of bone seems to occur earlier than normally in animals that have had access during all or a greater portion of their lives to alkali water, or to vegetation grown on alkali soil. The same is true with reference to the cartilage.

In addition to the probable influence of water and diet, the sex of the animal also has an influence on the color and hardness of bones and cartilage. The female normally matures more rapidly than the male and when the animals are grown under similar conditions this maturity is reflected in the color and hardness of the female's bones and cartilage earlier than in those of the male.

The bones of veal and young calves are relatively red and soft. They become whiter and harder as the animal grows older until they are creamy white to grayish white in mature animals, depending on their ages and the water and diet they have had. This process continues with age until the bones become grayish white to white and flinty in very old animals.

Following are some of the characteristics of the spinous processes of beef carcasses that are associated especially with the age of steers and, to a large extent, with those of heifers:

Yearling: Relatively soft bones, wide and prominent "button" or cartilaginous tips on the ends of the spinous processes of the forequarter.

Two-Year Olds: Relatively soft bones becoming harder; partially red, porous interior, turning slightly gray or white; buttons still prominent but becoming hard.

Three and Four-Year Olds: Bones almost entirely grayish white or white; noticeably hard but still somewhat porous; buttons smaller and hard.

Five-Year Olds and Older: Bones white and hard; buttons small, nearly absorbed and bony.

Experiments with mechanical equipment on cooked rib-eye muscles have shown, contrary to general belief, that with occasional exceptions the meat of calves (excluding veal) is somewhat less tender than that of yearlings of the same grade and that the meat of yearlings becomes somewhat more tender as it grows older until the animal reaches about 2 years of age. Thereafter it gradually becomes less tender. However, tenderness in cooked meat also depends on the method of cooking and its effectiveness in breaking down the connective tissue.

As a general rule, tenderness of beef in the same grade decreases with age after the animal is about 20 months old. Although there are exceptions it has a tendency to improve with grade in any given age group.

Each age group has its distinctive flavor. In general, the flavor of beef becomes more intense with age in the same grade but improves in desirability as the grade improves in any age group. Because of the greater fatness in the higher grades the intensity of flavor, especially of the lean, is modified. In general, this results in a more desirable flavor of the cooked meat, despite the fact that the desirability of the flavor of fat apparently decreases as its quality increases. In this respect, however, flavor is a matter of taste and varies in desirability with the peculiarities of the preferences of individuals.

Since shades of color and degrees of hardness of bone are characteristics in beef that are related to the age of the animal, and since age affects the tenderness and flavor of beef, color and hardness of bone are, to that extent, indications of the palatability features -- tenderness and flavor. Tenderness of beef in any age group has a tendency to increase as the grade improves or with the increase of finish or fatness, but the intensity of flavor generally is modified and the meat, especially in the highest grades, is more pleasing to the taste. In other words, the flavor in beef generally becomes more intense or more "beefy" as the animal grows older but it appears that this tendency may be modified somewhat and made more desirable at any age by the presence of abundant fats that are characteristic of the highest grades.

Color, Consistency, and Hardness of Cartilage: The cartilages to which reference is made are the pearly white formations on the ends of the bones that terminate in the flesh, such as the tips or buttons on the spinous processes or the ends of ribs. These formations also are at all joints, including the cushions between the vertebra.

In young animals the cartilage or buttons on the spinous processes are wide, prominent, soft, resilient, and pearly white. As the age advances they harden and grow relatively smaller by gradually becoming a part of the bone, and finally the cartilaginous substance almost disappears. The color likewise changes to some extent with the changes in consistency and becomes more nearly like that of the bone of which it is a part, or grayish white. As a rule, the demarcation between the cartilaginous tip and the bone is evidenced by a band of red due to the presence in that area of a greater amount of blood than is retained in the surrounding structure.

In order to illustrate further the changes that occur in the character and consistency of the "buttons," the following is quoted from the War Department Inspection Manual, Bulletin No. 16, issued May 15, 1918:

Age in years	Appearance in steers	Appearance in cows and heifers
2	Small, red spots begin to appear	After 2 or 3 years no buttons are present
3	Red areas more numerous	do
4	Small, bony islands form	No buttons are present
5	More bone than cartilage	No buttons are present
6	Only narrow strip of white cartilage left surrounding bone that has formed, but lines of demarcation between spines and buttons are distinct	No buttons are present
9	Buttons are solid bone	No buttons are present
12	Buttons of the same color as the bones of the spines, i. e. light in color	No buttons are present

The foregoing has not been verified by recent tests, but from general observation they are believed to be approximately correct. There are relatively few steers slaughtered in the United States that are more than 5 years old.

A correct judgment of quality and palatability cannot always be formed entirely by observing the degree of color and hardness and the character of bone and cartilage, but must take into consideration the possible influence of other elements that are associated with quality and palatability. In general, however, the color, the consistency, and the hardness of cartilage, especially of the "buttons," are associated with the age of the animal, and age is associated especially with the palatability features - tenderness and flavor.

Color, Firmness, Moisture, Grain, and Texture of Lean Beef: Age affects the color, grain, and texture of the lean of beef and, subject to the influence of finish, it also affects its firmness. Insofar as these three conditions are associated with age, which affects quality and palatability, especially tenderness and flavor, to that extent they may be used as indications of quality and palatability. It is obvious, however, that if these conditions, especially color, are thus associated with or influenced by age, they must be considered along with other evidences of quality and palatability and that due consideration must be given to the possible exceptions.

Although the shade of red in the lean meat is definitely associated with age, and ranges from a very light or pinkish shade of red in veal to a very dark, dull red in the lean of beef from old cattle, there are numerous exceptions to this rule, the causes of which are not fully known but are the subject of research. Furthermore, at any age the red of the lean in the higher grades of beef appears to be lighter and relatively brighter than in the lower grades because of the intermingling of abundant visible and invisible fat substances and juices in well-finished beef, which gives the lean a brighter red cast than it otherwise would have. Barring the exceptions, however, the shade of red in the lean of beef deepens and becomes duller with age, ranging from the pale red of veal to the much darker and duller red of beef from old cattle. Usually, however, the deepest and brightest red seems to be in well-finished beef from steers and heifers about 16 to 24 months old. From about the 2-year-old stage the lean of beef in a given grade takes on a darker color and a duller cast or hue of red with increasing age.

Color of lean when related to age is an indication of quality and palatability, especially insofar as tenderness, flavor, and juiciness are affected by age. Judgments in this respect, however, must be adjusted according to the degree of finish and corrected according to the probable effect of this degree of finish on quality and palatability. The distinctive color of lean which is associated with age may be associated also with the relative tenderness and the distinctive flavor which also are associated with age. To that extent, color of lean, considered in relation to the degree of finish, is an indication of the tenderness and flavor of beef. As a rule, abundant visible and invisible fat distributed through the lean gives the lean a more pleasing although not a more intense flavor. Less fat permits the natural characteristic flavors of the lean and connective tissue to be brought out without material modification by the flavor of excessive oils. The desirability of flavor in this respect, however, is a matter of individual taste.

Firmness: The relative firmness of meat, including both lean and fat, is an indication of its quality and palatability. This statement applies more particularly to lean meat in which firmness is caused largely by the degree and character of finish or the degree to which the visible and invisible fats and attendant meat juices are present and distributed through the lean. It does not apply to the so-called "thin and dried out" beef, which is not emaciated but is of low grade and often quite firm, despite the fact that it is practically devoid of much of the natural juices and fats that are characteristic of firm, well-finished beef.

Well-finished or high-grade beef, especially steer and heifer beef, generally is the most firm of all grades, while beef in each succeeding lower grade, barring the exceptions, has a tendency to be softer than it is in any higher grade. The relative degree of firmness in meat in relation to its quality is caused by the relative amount, consistency, and character of its juices and visible and invisible fats which surround and permeate the muscle fibers and connective tissues. These substances, which contribute to the relative degree of firmness of the meat also contribute to its relative juiciness and to the character or richness of those juices. They also have an influence on its tenderness and flavor.

Subject to the influence of age and to the possible exception mentioned (the "thin, dried-out" beef) meat that is firm when uncooked, usually is tender and has a desirable flavor when cooked, especially when the firmness is associated with excellent finish or abundant fat. In general, the softer, less finished lower grades of beef, making due allowance for age, are, when cooked, relatively less tender with each succeeding lower grade, provided the method of cooking is held constant.

Firmness in uncooked meat is caused by the "setting" or solidifying of its component elements, including the lean, fat, and juice, in their natural positions by rigor mortis, generally at relatively low temperatures, so that they are, in effect, bound or cemented together and offer more than usual resistance to pressure and do not shift readily from the positions in which they were when the flesh became firm. As a result, the flesh of high-grade chilled beef, which has a very high proportion of the fats and meat juices, is firm and resilient or has a tendency to return to its original position after pressure. Barring the thin, dried-out beef, this tendency becomes less apparent in each lower grade, in which the fats and juices are less abundant, until in the lowest grades there is practically no resistance or resiliency. That is the beef usually is very soft and inclined toward emaciation.

Since the degrees of firmness generally vary with the grades in descending order from very firm to very soft and since the degrees of quality and of palatability, especially of tenderness, juiciness, and flavor, generally vary likewise, the degree of firmness provides a reasonably reliable guide to quality and palatability.

At any rate the firmest meat generally is considered to be of the best commercial quality and, therefore, of the most desirable palatability, while the opposite is true of very soft meat.

Free Moisture: The flesh, especially the lean of beef, is composed largely of water. The proportion of water decreases from the lowest to the highest grades. It decreases about 5 percent with each next higher grade. The lean of the Good grade is about 50 percent water. A considerable proportion of this water shows on the cut surface in the form of free moisture. This moisture should not be confused with condensed moisture which may accumulate on the cut surfaces of meat.

By free moisture is meant the decidedly thin, watery liquid which exudes from and collects on the cut surfaces of some beef in drops or beads and often collects in small pools when depressions are made. This kind of moisture is more or less free flowing and is unlike, and should not be confused with the more substantial or fat enriched juices that generally exude less copiously from the cut surfaces of high-grade beef. The latter juices consist of considerable oily or invisible fat substances and rich meat extractives which cause the cut surfaces of the meat to feel smooth, "velvety," or "slick" and give it the brightness or sheen usually characteristic of high-grade beef. There is, however, a noticeable friction when the cut surfaces of meat with thin, watery, exudations are rubbed or palpated and the cut surfaces usually appear dull, faded, and otherwise unattractive. This is noticeable especially in most low-grade beef, in which there is a tendency for the lowest grade or that approaching emaciation to show the most "watery" moisture on the cut surface. The so-called "thin and dried-out" beef, found invariably in the low grades, is one of the possible exceptions.

It appears that as cattle are finished there is a tendency for visible and invisible fats to replace the watery content of the muscle fibers at least relatively. Therefore, well-finished beef or beef of high-grade apparently not only has less water in the lean tissue but less thin watery substances exude and accumulate on the cut surfaces.

The character and consistency of the exudations are general indications of the juiciness in cooked meat which is considered one of the elements of palatability. Apparently greater quantities of juice are retained in the cooked meat of the higher grades than in that of the lower grades and because of the greater quantity of melted fat in the juices its quality or character is much superior to that of the lower grades. The character of juice in meat has been defined as "the relative degree of richness and smoothness of the meat juices," and it has been said that "it depends on the concentration, in the juice, of meat solids, including fat." 2/ (See footnote page 1.) It appears that the character of the exudations has a tendency to reflect the consistency of the flesh which is also related to grade. The relative amount and character of the exudations on the cut surfaces of beef, therefore, may be used as one of the guides in appraising its grade and therefore its quality and

palatability, with special reference to juiciness, tenderness, and flavor. In general, the beef that exudes the greatest amount of free moisture is inclined to be driest and toughest when cooked and therefore in a very low grade.

Grain: Grain is a term commonly used in describing certain characteristics that appear on the cut surfaces of beef. It is used to describe a phenomenon of the muscle structure caused largely by the size, character, and position of the muscle strands or small muscle bundles and the connective tissue within the major muscles. Apparently the term has been adopted to describe a characteristic in meat that is quite similar in appearance to the grain in wood. Unfortunately, it is often confused with texture, although the two words as correctly and generally used have very different meanings.

Grain in meat has been defined as follows: 3/

> "Grain in meat refers to the natural size, structure, and positions of the muscular fiber bundles in relation to each other as exposed on any cut surface and usually with reference to a cross section of the muscle. Meat of large fiber bundles when cut across presents a coarse grained appearance while meat of small fiber bundles similarly cut presents a fine grained appearance."

The character of the grain in beef indicates quite generally its age. Young beef has small muscle strands within the major muscle units, while beef from older animals has much larger muscle strands and more noticeable connective tissue. The sinewous tissue associated with the muscles also varies in size or quantity in like manner and contributes to the appearance of the grain in meat. It sometimes is confused with marbling, as often is the case when it appears in the beef of old cattle. Thus a fine grain is characteristic of the flesh of young cattle and a coarse grain is generally characteristic of the flesh of old cattle. Since grain indicates age, more or less, in like manner it is associated with tenderness and flavor. To that extent, the grain of beef provides a guide to quality and palatability, but judgments in this respect must be adjusted to meet the influence of finish and of the other elements that affect quality.

Texture: Texture also is a term used to describe certain characteristics in beef that are associated with its firmness and quality. A definition committee composed of Federal and State meat research workers 4/ has defined texture in meat as follows:

> "Texture in meat is its natural structure which results from the binding together of its component parts in relative natural positions, largely by connective tissue."

3/ Definition prepared by a committee on definitions and approved by a committee of interbureau and State experiment station meat research workers, October 21, 1938.

4/ See footnote 3.

By texture is meant the manner and degree to which the component elements of meat are bound or "cemented" together in their natural positions so as to give the meat varying degrees of adhesiveness, resiliency, and solidity or firmness and to preserve a relative smoothness or continuity of cut surfaces. Texture, therefore, contributes primarily to the relative degree of firmness in meat but the influence of texture on firmness depends to a large extent on the degree of finish. Well-finished beef has tight texture because the connective tissues are stretched or filled with fats and juices of high quality and consistency; while the opposite is true with reference to poorly finished beef. To the extent that texture is thus affected by finish, texture, like firmness, is an index of quality and palatability.

The cut surfaces of well-finished, firm beef, at any age, will remain in their natural positions when cut and return to their positions after pressure. Such meat is well bound together and has a good or tight texture. The component elements of soft or poorly finished beef are easily pressed out of their original positions to which they do not readily return after pressure or handling. Such beef has poor or loose texture. The gradations from the tight texture of firm beef in the high grades to the loose texture of soft beef in the low grades are associated with the grades in descending order and, approximately in the same order, are indications of relative quality and palatability of the meat. Low-grade beef that is dry and thin and that has tight texture is an exception to the general rule in this respect as it is in firmness. It has tight texture but lacks finish and much in tenderness. This characteristic, also found in much bull beef, makes that kind especially desirable in the manufacture of certain kinds of sausage.

Color, Character, Quality, Quantity, and Distribution of Fat: The color of fat in beef is a general but not an infallible indication of its grade, quality, and palatability. Color of fat is influenced to a considerable extent by the kind of feed used, also by age, breed, and sex. Usually the fats in beef of cattle that have been finished on dry feeds, including grain, other concentrates, and bright hay, are relatively white to creamy white, firm, abundant, and well distributed. The beef almost invariably is in the high grades. The fats in beef of cattle that have had access to grass, green hay, or other similarly high-colored feeds, almost invariably have a yellowish cast, in a technical sense correctly described as greenish yellow. The fat of "grass cattle" is an example. The greenish tint is usually very light and is caused mostly by the green or amount of chlorophyl in the grass, hay, or other feeds. It does not refer to the greenish areas on the carcasses caused by grubs. The fats of old animals, and especially cows of certain dairy breeds, are inclined to have a deeper shade of yellow than those of younger animals.

Although white to creamy white fats and yellowish[5/] to greenish yellow fats may be found in animals of any degree of fatness, depending

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5/ Yellow fat is rich in carotin and, therefore, may exceed white fats in food value, especially so far as vitamin A is concerned.

on the kind and quantity of feed given, abundant relatively white to creamy white firm fats of excellent quality are more generally characteristic of the highest grade of beef. The yellowish to greenish yellow fats, however, more generally occur in the lower grades, and in such cases they are almost invariably soft and poorly distributed.

In general, therefore, the gradations between the white to creamy white, firm, wax-like, well-distributed fat, usually characteristic of the highest grades, and the yellowish to greenish yellow, especially soft, low-quality fats, more generally associated with the lower grades may be used as indications of relative quality and palatability of beef in descending order. This applies especially to the extent that these gradations are related to age and grade.

Character or Quality of Fat: The quality of fat is its degree of excellence, largely from an oil content or oil yielding standpoint. The quality of fat is closely associated with and manifested by the character of the fat, especially by its degree of compactness, firmness, brightness, brittleness, waxiness, oiliness, and color. The significance of the color of fat is discussed in the preceding section. Abundant firm, brittle, or wax-like fats are characteristic of the high grades of beef, while soft, pasty, or lifeless fats or fats with a high proportion of connective tissue to fat content, or the absence of fat, are characteristics of the low grades.

In general, the gradations from abundant, firm, and brittle or waxy white to creamy or yellowish white fat of the high grades to the scant, soft, or oily, often yellowish to greenish yellow fats of the low grades correspond, in descending order, with the gradations in quality and palatability in relation to the descending grades. Abundant, well distributed fats of high quality and excellent consistency, as a general rule, indicate high quality in the uncooked beef and usually very desirable palatability in the cooked beef, especially with respect to tenderness, juiciness, and flavor; while the opposite is generally true in beef with fats of low quality and of poor consistency and character.

Quantity and Distribution of Fat: By quantity and distribution of fat are meant the degree of fatness or finish and the extent and manner in which the fat is distributed over the exterior and interior surfaces of the carcasses or cut and between and within the muscles.

The quantity and distribution of fat together with its quality and character are more than ordinary indications of quality and palatability in beef. In combination, they indicate the measure of success in finishing beef cattle. The quantity of fat while important is not as significant of quality and palatability of beef as are the character and distribution of fat. Carcasses or sides may be well covered on the surfaces inside and out with excessive fats but the interior fats, although they may appear to be of high quality, may not be of sufficient quantity or so well distributed through the lean in the form of marbling and invisible fats as the exterior fats might indicate. Such carcasses are often referred to as "counterfeits."

Most experienced beef men are able to differentiate with reasonable accuracy in such cases before the sides are quartered. There can be little question in this respect, however, when the sides are quartered or converted into commercial cuts. There are many but generally little known features in the sides that beef men take into consideration when determining the character and distribution of fat through the lean in the form of marbling and invisible fats, and therefore the quality of beef. As a rule, several of such features must be appraised before reliable judgments can be formed. Among those features are:

Conformation or the natural thickness of flesh and the degree to which it is dependent on fats deposited within the muscles.

Brightness and character or quality of the visible fats.

Extent and character of the fat covering or plating over the inner walls of the forequarter.

Deposits of fat in the lean between the ribs.

Extent, smoothness, color, and firmness of the fat over the exterior surface as against similar characteristics of the fat deposits on the inner walls of the sides.

Amount, color, and character of the fats in the crotch and cod of the steer or in the crotch and around the udder of the heifer.

Character, color, and generally the amount of fat around the kidneys.

Thickness and firmness of the flank.

Fat deposits on the flank muscle or "flank steak."

Fats exuding from spaces between the dorsal spinous processes, especially of the forequarter.

Marbling and other fat deposits in the exposed lean at the top of the chuck and neck or crest, together with the color and dryness of such muscles.

Relative brightness or sheen, according to their character, of all exposed muscles, especially those of the brisket.

There are, no doubt, many other features in a side of beef which may be used as indications of the character and distribution of fat through the lean, and therefore of the quality and palatability of the beef. The so-called invisible fats are the animal oils in suspension with the meat juices and extractives while the animal was living. These animal oils remain more or less in that condition after slaughter, that is, they do not crystallize in the form of solid, visible fat but are none the

less present among the muscle tissues and tend to give the lean tissue a brighter red appearance and a greater smoothness to the touch than it otherwise would have. The distribution of abundant but not too wasty solid fats of high quality over the carcass, over the broad, thin exterior muscle of the plate, on its interior walls and parts, between the muscles, and within the muscles in the form of fat nodules and irregular fat streaks (marbling),[6] and invisible fats as manifested in the brightness or sheen of the red in the lean, are characteristic of the highest grades of beef. The total or almost total absence of these phenomena are characteristics of the lowest grades of beef. The gradations between these two extremes in the descending order of the grades of beef are indications, in the same order, of its quality and palatability, with special reference to the tenderness, juiciness, and flavor of the cooked meat.

In general it is believed probable that the absorption into the lean of the melted fat particles, including those from the marbling and the invisible fats contributes materially to the superior palatability of high quality cooked beef and especially to its tenderness and desirability of flavor. In the proportion that these natural fats are absent is there generally a corresponding decrease in the palatability of the cooked meat, especially insofar as tenderness, juiciness, and mildness of the flavor of beef are concerned. The degree of decrease in palatability, of course, depends again upon the method of cooking. There is, however, generally a more intensely "beefy" flavor, or the flavor of lean and connective tissue (protein) in the less finished or low-grade beef than in the high-grade beef, because of the absence of the moderating influence of abundant melted, natural fat.

The variations in the quantity and quality of fats, from an abundance of excellent, well-distributed fat to scarcely any fat of poor quality and character, correspond to a large extent, with the variations in the quality of the uncooked beef and in the palatability of the cooked beef.

Thickness of Flesh: By thickness of flesh is meant the ratio of meat, including both lean and fat, to bone. Thickness of flesh is related primarily to conformation, which is one of the three grade factors.

Although thickness of flesh implies a ratio of meat to bone, it is of significance also as indicating quality and palatability. A cut of beef that has a proportionately greater natural thickness than usual, barring that from bulls and stags, indicates that it has more natural meat substances in the form of meat juices, visible and invisible fats, probably larger muscle cells, and usually relatively less connective tissue than are customarily found in similar cuts

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6/ Marbling as used here, refers to visible fat deposits only and should not be confused with thick sinewous tissues, which are more apparent in beef from old cattle, especially cows, and which have the appearance of fat or marbling.

which are not so thick, but are from cattle of the same breed, class, age, and grade with somewhat different conformation. The principal indication is relatively greater tenderness because a sample of such meat cut from a given area usually has less connective tissue per unit weight than a similar sample of the same weight cut from the same area of somewhat thinner beef of the same grade.

Connective tissue is the principal source of toughness in meat. It is hardly probable that a given muscle of one animal has more cell units than the same muscle in another animal of the same kind, and it is not probable that they increase in number in any given muscle with grade, but it is possible for those cell units to vary in size according to the efficiency of the animal in utilizing nourishment. Hence it appears that there are different degrees of conformation, due primarily to different thicknesses of muscles as well as differences in the deposits of fat. Visible and invisible fat deposits and juices among the muscle fibers and tissues also contribute to the thickness of muscles and cuts.

Whatever may cause a given cut of beef to be thicker than similar cuts from other beef carcasses that are similar in practically all other respects, it is nevertheless true that such thick cuts generally give greater satisfaction than the other cuts similarly prepared, because they apparently have relatively less connective tissue and are therefore more tender than the other cuts. It is possible also that the connective tissue of such meat has been so distended or stretched by greater quantities of meat juices and oils that they may be relatively weaker and that the meat is therefore more tender than a similar thinner cut of meat of the same general description.

Thick, blocky, well-rounded beef is characteristic of the better grades while there is a tendency toward thinner, flatter, and "stringier" beef with each lower grade. Since quality and palatability are in general associated with grade the thickness of the flesh provides a general indication of the quality of the uncooked meat and of the palatability of the cooked meat. Cuts of beef from carcasses with thick flesh usually are more tender than similar cuts from carcasses with thin flesh. A given sample of meat from a carcass with thin flesh has more and probably tougher connective tissue to a given unit of measurement or weight than a similar sample from a carcass with thick flesh and is less palatable or pleasing to the consumer than the meat of the thicker carcass, especially so far as tenderness is concerned. Relative thickness of the flesh, therefore, may be used as a guide to relative quality and palatability, especially with respect to the tenderness and also to the juiciness and flavor of the cooked meat.

Tenderness and Flavor Affected by Time: Practically all evidences of quality and palatability in beef are related in some manner to its tenderness and flavor. A careful appraisal of all such evidences separately and in combination provides a reasonably reliable basis for estimating the approximate tenderness and flavor of beef.

Certain adjustments in judgment are advisable, however, to allow for certain physical changes affecting tenderness and flavor that occur in beef during the period it is held in storage.

It appears that all beef is less tender immediately after it has become set and firm from rigor mortis than it is immediately after slaughter or after it has been held for a considerable period to age and ripen. In general, however, autolysis or dissolution of the flesh starts immediately after death and, if not retarded eventually results in complete decomposition. In the processes of dissolution the fibers and connective tissues gradually break down through fermentation or enzymatic action and the meat becomes increasingly more tender. This process is retarded but not completely stopped by refrigeration. It is speeded up by withholding refrigeration. Under refrigeration the fresh meat is preserved in edible condition for an indefinite period during which the beef is aged or ripened. This process results in certain changes that not only weaken the connective tissue but affect the flavor of the meat. An appraisal of the tenderness and probable flavor of beef, therefore, should take into consideration the approximate time and conditions under which the meat has been held after slaughter. Any reliable appraisal of tenderness and, to a large extent of flavor, must take into consideration not only these evidences of tenderness in relation to palatability that have been discussed, but it must take into consideration also the effect on tenderness and flavor caused by fermentation and autolysis during the lapse of time after slaughter and the conditions under which the beef has been held.

Aged and Ripened Beef: The aging or ripening of beef is a special process of holding it in storage under controlled temperature and humidity, the purpose of which is to cause greater tenderness and to add a distinctive flavor to the beef. Although the dissolution or breaking down processes begin immediately after slaughter, the fermentation or enzymatic processes could be hastened materially if the meat were held at high temperatures. This, however, would tend also to hasten its spoilage much earlier unless proper methods of preventing spoilage were used in lieu of those customarily used when the meat is held under controlled refrigeration and humidity.

Aging or ripening beef under refrigeration, using the customary cold storage temperature, retards the fermenting processes and causes the connective tissue to weaken and break down at a relatively slow rate. Meanwhile, the enzymatic action on the muscle cells and connective tissues so affects the meat as to give it not only relatively greater tenderness but a characteristic flavor. The effects of aging and ripening beef are usually more satisfactory with well-finished or high-grade beef than with low-grade or poorly finished beef. It is believed that the presence of fat, both visible and invisible, well distributed over, between, and within the muscles to a certain extent prevents the rapid decomposition of the meat and also tends to influence the character of the flavor developed by the enzymatic action whether the meat is aged under refrigeration or is otherwise treated to improve its tenderness and flavor. (See page 4.)

Aging and ripening beef by any method constitute, in effect, a method of processing because they produce changes in the tenderness and flavor of the meat through fermentation or enzymatic action. These changes affect different grades of beef differently. Low-grade beef and the meat of young animals that, grade for grade, usually lack the finish of beef from older animals, do not age as satisfactorily as well-finished beef and they are inclined to break down and decompose much earlier. Aging and ripening beef so change the condition from the standpoint of flavor and tenderness that a different general grouping from that of strictly fresh beef is necessary. The grading of aged or ripened beef, therefore, should be adjusted to those changed conditions, especially insofar as they affect the probable palatability of the meat.

Since the beef was of a given grade when it was dressed and chilled, it seems logical that grade should be retained regardless of the changes caused by aging or ripening. The conformation and finish will be the same, while tenderness and flavor may be different but peculiar to that grade of meat after it was given the aging or ripening process. That is, if a carcass was correctly graded Choice immediately after slaughter and chilling, it would still be Choice, but Choice ripened beef after it had been put through the aging or ripening process and it would be in that grade so long as it is edible. In other words, the artificial processes of aging or ripening beef do not change its grade from that to which it was entitled immediately after slaughter and chilling.

Eye Appeal: The general appearance of beef is not an infallible guide to its quality and palatability, especially to its tenderness and flavor; but, on the whole, the attractiveness of beef may be relied upon as an indication of the satisfaction it will give when prepared and eaten. Most of the factors indicating quality and palatability that have been discussed, contribute in varying degrees to the appearance of the uncooked meat in proportion to their presence in the meat. These factors range from the brightness, solidity, and richness of its substances in the high grades, to the dullness, softness, and poverty of these substances in the low grades. Especially is the appearance of the uncooked meat affected by the color and character of lean, fat, and bone; by the distribution and character of fat and its effect on the composite color of meat; by the texture and grain of the meat; by its thickness, firmness, and shape; and by the character and effect of the moisture on the cut surface. Probably the composite color of meat, together with its firmness, determines its eye appeal more than any other characteristic. Relatively firm, bright red lean beef with its attendant marbling and surrounding white or creamy white fats, characteristic of the high grades, appeals to the eye more effectively than the soft, dark, or duller red beef with scant yellowish fats, more or less characteristic of the low grades. In general, these characteristics "step down" noticeably from one grade to that next below it.

Those gradations of color and of the other indications of quality and palatability of which the eye takes note, extending from those associated with the high grades to those associated with the

low grades, may be accepted with reasonable assurance as indications of the grades of beef in descending order and therefore of its relative quality and palatability in the same order.

Some beef will cut bright and remain bright. Some will cut bright and slowly turn darker. Some will cut dark and become brighter, but some will cut "dark and gummy" and remain in that condition. Beef that cuts dark does not appeal to the eye. Dark cutting beef, the cut surface of which suggests "gumminess" to sight and feel, usually has a tendency to remain dark; whereas beef that cuts dark but which lacks the gummy characteristic, often becomes much brighter after exposure to the air. As a rule, the dark and especially the dark gummy beef is discriminated against by those who are seeking beef of above average quality and palatability. It has not been established beyond question of doubt, however, that such beef is lacking in the palatability elements of tenderness and flavor expected of brighter cutting beef of the same degree of finish and age. Few can detect any material difference under test after the meat is cooked, although many claim that dark gummy beef is much less tender than bright cutting beef when both are cooked in the same manner.

Since beef that cuts dark is discriminated against and often materially discounted when sold on the market and since such beef is usually difficult to detect in the side, graders have endeavored to find external evidences that are apparent before the side is quartered of the color and character of the beef. In addition to what a careful examination of the exposed fat and lean surfaces reveals, no infallible index of dark and "gummy" cutting beef has been discovered.

Quality, Palatability and Nutritive Value

Many consumers associate the quality or grade of meat with its nutritive value or assume that the grade is a guide to the quantity of nourishing elements contained in the meat. The principal food elements in meat are protein and fat. The importance of ash, which is usually less than 1 percent of the edible meat, apparently is of minor consideration. The fourth chemical element is water.

Protein (derived from lean and connective tissue) and fat are the principal sources of nourishment in meat. Since they vary in proportions according to grades, the relative food values of meat are indicated by the grades. As the grades improve from the lowest to the highest the proportions of fat increase and the proportions of protein decrease. The proportions of water also decrease. The increase in the proportion of fat is greater than the decrease in the proportions of protein and water. It would appear, therefore, that the total food value content of beef increases as the grade improves.

It has been shown that the palatability of beef also becomes more desirable as the grade improves. Therefore the grade of beef is an indication not only of its degree of palatability but apparently also of its relative food value.7/

7/ See Department Circular No. 389 "Proximate Composition of Beef" U. S. Department of Agriculture, 1926.